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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Improvements in or relating to Hydro-Kinetic Apparatus

We, HEENAN & FROUDE LIMITED, a British Company, of Worcester, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention relates to hydro-kinetic apparatus, more particularly hydro-kinetic brakes and hydro-kinetic couplings or clutches, and has for an object to provide improved such hydro-kinetic apparatus suitable for use in wheeled vehicles and in industrial and other installations.

The hydro-kinetic method of braking is well known and heretofore it has been proposed to couple the braking member of an hydro-kinetic brake in a permanent manner to the shafting system to be retarded, and the degree of retardation varied either by altering the liquid filling of the brake by known means, or by the interposition of sluice plates between the rotor and stator of the brake. Maximum braking power is approximately proportional to the cube of the speed of rotation of the braking member, and the brake may have to be made of such a size as to give relatively large braking effort at comparatively low speeds, whereas the maximum running speeds may be quite high.

When the braking effort is controlled by either of the means above referred to, the minimum braking effort at high speeds will be appreciable. For example, if 100 H.P. of braking effort is required at 1000 r.p.m. and the maximum speed of the brake under conditions where braking is not required is 4000 r.p.m., the inherent capacity of the brake at this latter speed would be approximately 6400 H.P. Even supposing all the liquid is taken from the brake under these conditions, the air contained in the brake would still give approximately 1/800th of the braking force obtained with water, that is to say 8 H.P., but, since in practice with no air circulation the brake would heat, it is usually necessary to add some water to keep the brake cool and this again results in an increase in the minimum power absorption at the higher speed. In many applications, such as for instance internal combustion engine driven road vehicles, this implies a serious loss of operating efficiency, since in addition to driving the vehicle, the engine also has to overcome this minimum braking effort.

One way of avoiding such loss of operating efficiency is to provide a clutch between the brake and the shafting system to which it is normally connected. When this arrangement is adopted, the clutch has to accelerate the rotatable parts of the brake before full braking can be applied, and is a complication to be avoided if possible.

Acording to the present invention, there is provided an hydro-kinetic apparatus, more particularly an hydro-kinetic brake or an hydro-kinetic coupling, comprising a housing defining a fluid pressure chamber having fluid inlet and fluid outlet means, a rotor positioned within said chamber and secured upon a shaft rotatably supported by the housing, a stator positioned within the chamber and freely rotatable with respect to the rotor, valve means for varying the flow of fluid into the chamber, and means for restraining the stator against rotation when it is required to exert a braking effort on the rotor, the said outlet means including a leakage path surrounding the stator and extending axially between the stator and the housing for opposing the free outflow of fluid from the chamber and having a predetermined pressure-flow characteristic.

The term "stator" is used in the present

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specification to define a member which in fact is rotatable because when the apparatus is used as a brake, the said rotatable member is secured against rotation and becomes in effect a stator co-operating with the rotor to apply braking torque thereto.

Conveniently, the stator is secured upon a stator shaft rotatably supported in the housing for rotation independently of the rotor-supporting shaft. Alternatively, the stator may be freely rotatably supported upon the rotor supporting shaft. The said restraining means may comprise a known form of positive brake, for example a friction brake, one member of which is connected to the stator for rotation therewith and the other member is supported by the housing or other stationary part of the apparatus. Thus, under normal running conditions of the hydro-kinetic brake and when braking is not required, the positive brake is disengaged and the fluid contained in the chamber will cause the rotor and stator to interact in the manner of an hydraulic clutch or coupling. However, since the stator is free of restraint, it will rotate at a speed approximating that of the rotor and the amount of power absorbed under these conditions is negligible. When braking is required, the positive brake is applied and the stator brought to rest, and the arrangement becomes, in effect, a conventional type of hydro-kinetic brake which can be controlled by known means normally used for the control of the retarding effort of brakes or hydraulic dynamo-meters or by the means hereinafter described.

The invention will now be more fully described with reference to the accompanying drawings, in which:—

Figure 1 is a longitudinal section through an hydro-kinetic brake according to the invention; and

Figure 2 is an alternative construction of brake which can also be employed as a variable speed coupling.

Referring to Figure 1, the hydro-kinetic brake comprises a housing 1 formed to provide a chamber 2 in which are positioned a rotor 3 and a stator 4. The rotor 3 is secured upon a shaft 9 rotatably supported in end plates 16 and 13 by bearings 5 and 6 respectively. The stator 4 is secured to a sleeve 10 rotatably supported on the shaft 9 by bearings 7 and 8. The rotor 3 and stator 4 has vanes 33 set at 45° to the plane of the opposing rotor and stator faces and inlet ducts 34 are formed in the vanes 33 of the stator for admitting fluid to the working compartments or cups 26 formed between the vanes 33 of the rotor 3 and the stator 4 respectively. Alaternatively, the inlet ducts may be formed in any other convenient part of the stator. Attached to the stator-supporting sleeve 10 is the rotatable member of a positive brake, for example, the drum 11 of a drum-type friction brake, the non-rotating member 12 of which together with required operating gear (not shown) is attached to the end plate 13.

A vaned pump 14 is supported upon the rotor shaft 9 for rotation therewith and rotates in a chamber 15 formed by the housing 1 and the end plate 16. The pump inlet is provided by a fluid passage 17 leading to an inlet compartment 18 having straightener vanes 19 positioned therein. Fluid from the pump chamber 15 flows through passages 20, 22 and 23 to a fluid inlet compartment 24 formed at the back of the stator 4 and from which fluid flows through the inlet ducts 34 to the working compartments 26. A valve 21 is interposed between the passage 20 and the passage 22 for controlling the flow of fluid from the pump to the working compartments. Labyrinths 27 and 30 are formed in the housing 1 on each side respectively of an outlet annulus 28 and outlet passage 29, the labyrinth 27 providing a leakage path surrounding the stator and extending axially between the stator and the housing, and suitable seals—as indicated for example at 31—are provided at all necessary points. A vent passage 32 extends through the clearance space between the opposing faces of the rotor 3 and the stator 4 to the centre of the working compartments or cups 26 thereby to ensure a quick response to changes in the amount of fluid in the chamber 2 and permitting a maximum controllable range of torque to be obtained.

In operation of the brake, when fluid passes through the space between the rotor 3 and stator 4, it is entrained in the vortex set up by the interaction of the rotor 3 and the stator 4. By reason of the pressure thus generated the fluid is then discharged into the annular space of the chamber 2, surrounding the rotor 3 and from thence through the labyrinth 27 to the outlet annulus 28, the pressure of the fluid being reduced in a controlled manner by the action of the labyrinth 27. The labyrinth 30 prevents excessive recirculation of fluid from the outlet annulus 28 back to the inlet compartment 24, under conditions where the fluid pressure in the outlet annulus is greater than that in the inlet compartment. Conversely, the labyrinth 30 prevents excessive leakage of fluid from the inlet copartment 24 to the outlet annulus 28 and/or to the chamber 2 when the fluid pressure in the inlet compartment 24 is greater than that in the annulus 28 and/or the chamber 2.

For a given speed of rotation of the rotor and stator, the torque transmitted from the rotor to the stator, will depend upon the amount of fluid in the rotor and stator cups 26, which in turn depends upon the fluid pressure in the chamber 2. Thus, by pro-

viding means such as the control valve 21 for variably controlling the rate of flow of fluid into the stator cups 26, the fluid pressure generated in chamber 2 can be controlled so as to maintain an outflow of fluid through the labyrinth 27 at the same rate as the inflow of fluid to the stator cups 26. This in turn will control the fluid filling of the cups 26 hence the torque transmitted from the rotor 3 to the stator 4. When the control valve is fully open the pressure generated in the chamber 2 will be a maximum and consequently the fluid filling of the cups and the torque transmitted will also be a maximum. Conversely, when the control valve is fully closed the pressure generated in the chamber 2 will be a minimum and the fluid filling of the cups and the torque transmitted will also be a minimum. For maximum operating efficiency of the brake the resistance of the labyrinth 27 to fluid outflow is designed to ensure complete fluid filling of the cups 26 when the maximum quantity of fluid is flowing through the brake. Furthermore, the maximum fluid flow must also be sufficient to prevent overheating when the apparatus is working under maximum capacity conditions.

By omitting the positive brake or when the positive brake is not in use and the stator is thus free to rotate the apparatus can be used as a variable speed clutch or coupling and in this case the torque transmitted by the driving member to the driven member and/or the differential speed between the driving and driven members is controlled by varying in known manner or in the manner hereinafter described the fluid filling of the troque transmitting elements.

One arrangement of variable speed clutch or coupling is shown in Figure 2 in which the stator *4a* is secured upon one end of a shaft *10a* supported at the other end in a bearing *8a* in the end plate 13. The rotor *3a* is secured upon one end of a shaft *9a* the other end of which is supported in a bearing *5a* in the end plate 16. The shaft *9a* is also supported intermediate its length by a bearing *6a* mounted in a hollow bushing *1b* formed integral with the housing *1a*, the shaft *9a* being provided at the said one end thereof with a recess 35 which accommodates a bearing *7a* supporting a reduced end portion 36 at the said one end of the shaft *10a*. The drum *11a* of the brake is also secured on the shaft *10a*.

In using the hydro-kinetic coupling arrangement of Figure 2 the shaft *9a* is connected to a driving shaft or member and the shaft *10a* to a shaft or member to be driven and the speed of the driven shaft or member and/or the torque transmitted from the driving shaft or member to the driven shaft or member can be varied at will within the torque range of the coupling or clutch by varying the rate of fluid flow through the chamber 2.

When it is required to employ the arrangement of Figure 2 as a brake, the friction brake is engaged to restrain the stator against movement and the fluid flow through the apparatus is controlled by the valve 21 to vary the braking effort exerted on the rotor.

The control valve 21 and the stationary member 12 of the positive brake are provided with known mechanical, hydraulic or electrical operating gear (not shown) arranged to ensure the correct sequence of operations. Thus when braking torque is required the positive brake is engaged and the stator brought to rest and the control valve is then progressively opened until the desired value of braking torque is obtained. Conversely, when braking torque is not required the control valve is progressively closed and the positive brake disengaged to allow the stator to accelerate to a speed approaching or equal to that of the rotor. Under this condition the braking torque on the rotor shaft will be neglibible.

In order to obtain quick response to changes of fluid filling of the hydro-kinetic brake or coupling and to obtain the maximum controllable range of torque, the vent passage 32 is provided although the brake or coupling will, however, function satisfactorily without this vent passage, but the range and rate of response of controllable torque may be reduced.

In certain applications of the hydro-kinetic brake or coupling it may be desirable for the torque transmitted from the rotor to the stator to be proportional to the square of the rotor speed. The said torque characteristic is obtained when the fluid pressure in the chamber 2 is developed at a rate equal to the square of the speed of rotation of the rotor. Thus by providing the chamber 2 with an outlet leakage path having a flow rate proportional to the square root of the rotor speed, and by supplying fluid to the hydro-kinetic brake or coupling at a rate proportional to the rotor speed, the desired pressure and torque characteristic can be obtained. One arrangement that has been successfully employed to give the said pressure and torque characteristic is by forming the labyrinth 27 by a plurality of grooves of square section $\frac{1}{8}'' \times \frac{1}{8}''$ and axially spaced at 3/16″ pitch to provide lands 1/16″ wide and having sharp corners. The minimum radial clearance between the lands and the periphery of the stator 4 is not less than .010″ to avoid the possibility of a transition to laminar flow through the said clearance. The rate of flow through this labyrinth is proportional to the square root of the pressure developed in the chamber 2 and since the pump 14 delivers fluid to the brake or

coupling at a rate proportional to the speed of the rotor, the aforementioned torque characteristic is obtained. It will be appreciated that by using other known means for varying the fluid filling of hydro-kinetic brakes or couplings, similar or other torque characteristics can be obtained to suit various practical requirements. Thus, for example, the valve 21 can be controlled by means responsive to the torque or to the rotor speed to give a desired torque characteristic. Further, the means of supplying fluid to the chamber 2 is not restricted to a pump rotating at a speed proportional to the speed of the rotor, but may comprise a suitable form of fixed speed pump, or other suitable pressurized means in which a pump may or may not be used.

As previously state, it is necessary to supply the hydro-kinetic brake or coupling with fluid at a rate sufficient to extract the heat generated therein. It is further necessary to provide the brake or coupling with some form of extrenal circulating system in which the said heat can be dissipated.

When using the apparatus as an internal combustion engine driven vehicle brake it can be operatively connected to the power transmission shafting between the engine and road wheels, and the fluid circuit of the brake can be connected to the engine jacket cooling system. The heat generated in the brake can either be dissipated in the normal manner or used to maintain correct working temperatures in the engine cylinder jackets during the descent of a long incline and/or to supply heat to the heating system of a passenger vehicle, or any other vehicle in which heating is required. Furthermore, when starting up a vehicle after standing in cold climatic conditions, any heating system dependent upon waste heat from the engine can take considerable time before it is of real benefit. It is therefore proposed that when hydro-kinetic braking is available, this should be used after the cold start of the engine and the heat so generated be fed directly to the vehicle heating system and until such time as the engine jackets are sufficiently warm to revert to the normal heating system. Hydro-kinetic braking can then be discontinued. A secondary benefit of such an arrangement is that the additional power required from the engine to drive the hydro-kinetic brake will speed up the heating of the engine jackets.

Finally, in industrial applications of the hydro-kinetic apparatus according to the invention, the heat generated in the said apparatus can, if desired, be used in any suitable heating system.

Having regard to the provisions of Section 9 subsection (1) of the Patent Act, attention is directed to the claims of Patents Nos. 736127 and 691556.

WHAT WE CLAIM IS:—

1. An hydro-kinetic apparatus, more particularly an hydro-kinetic brake or an hydro-kinetic coupling, comprising a housing defining a fluid pressure chamber having fluid inlet and fluid outlet means, a rotor positioned within said chamber and secured upon a shaft rotatably supported by the housing, a stator positioned within the chamber and freely rotatable with respect to the rotor, valve means for varying the flow of fluid into the chamber, and means for restraining the stator against rotation when it is required to exert a braking effort on the rotor, the said outlet means including a leakage path surrounding the stator and extending axially between the stator and the housing for opposing the free outflow of fluid from the chamber and having a predetermined pressure-flow characteristic.

2. An hydro-kinetic apparatus according to claim 1, wherein said restraining means comprises a positive type brake, for example a friction brake.

3. An hydro-kinetic apparatus according to claim 1 or 2 including a pump for supplying fluid to the chamber and driven at a speed proportional to the speed of rotation of the rotor thereby to supply fluid to the chamber at a rate proportional to the speed of the rotor, and wherein the said outlet leakage path has a flow rate proportional to the square root of the rotor speed whereby the torque transmitted from the rotor to the stator is proportional to the square of the rotor speed.

4. An hydro-kinetic apparatus according to any of the preceding claims, wherein the stator is freely rotatably supported on the said rotor supporting shaft.

5. An hydro-kinetic apparatus according to any of claims 1 to 3, wherein the stator is secured upon a further shaft mounted for rotation in the housing independently of the said rotor-supporting shaft and in axial alignment therewith.

6. An internal combustion engine driven vehicle provided with an hydro-kinetic apparatus according to any of the preceding claims.

7. An internal combustion engine driven vehicle according to claim 6, wherein the heat generated in the fluid of the hydro-kinetic apparatus is utilised to maintain the water jacket temperatures of the internal combustion engine at a required value.

8. An internal combustion engine driven vehicle according to claim 6 or 7, wherein the heated fluid discharged from the hydro-kinetic apparatus is utilised to supply heat to a heating system for the vehicle.

9. An hydro-kinetic brake substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

10. An hydro-kinetic apparatus suitable

for use as a clutch or coupling, substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

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PROVISIONAL SPECIFICATION

Improvements in or relating to Hydro-Kinetic Brakes

We, HEENAN & FROUDE LIMITED, a British Company, of Worcester, do hereby declare this invention to be described in the following statement:—

The present invention relates to hydro-kinetic brakes, more particularly though not exclusively to kinetic brakes of the Froude type, and has for an object to provide an improved hydro-kinetic brake suitable for use in industrial installations as well as in road or rail vehicles.

The hydro-kinetic method of braking is well-known and heretofore it has been proposed to couple the braking member of an hydro-kinetic brake in a permanent manner to the shafting system to be retarded, and the degree of retardation varied either by altering the filling of the brake by known means, or by the interposition of sluice plates between the rotor and stator of the brake. Maximum braking power is approximately proportional to the cube of the speed of rotation of the braking member, and the brake may have to be made of such a size as to give relatively large braking effort at comparatively low speeds, whereas the maximum running speeds may be quite high.

When the braking effort is controlled by either of the means above referred to, the minimum braking effort at high speeds will be appreciable. For example, if 100 H.P. of braking effort is required at 1.000 r.p.m. and the maximum speed of the brake under conditions where braking is not required is 4,000 r.p.m., the inherent capacity of the brake at this latter speed would be approximately 6,400 H.P. Even supposing all the liquid is taken from the brake under these conditions, the air contained in the brake would still give approximately 1/800th of the braking force obtained with water, that is to say, 8 H.P., but, since in practice with no air circulation, the brake would heat, it is usually necessary to add some water to keep the brake cool and this again results in an increase in the minimum power absorption at the higher speed. In many applications, such as for instance road vehicles, this implies a serious loss of operating efficiency, since in addition to driving the vehicle, the engine also has to overcome this minimum braking effort.

One way of avoiding such loss of operating efficiency is to provide a clutch between the brake and the shafting system to which it is normally connected. When this arrangement is adopted, the clutch has to accelerate the rotatable parts of the brake before full braking can be applied, and is a complication to be avoided if possible.

According to the present invention, there is provided an hydro-kinetic brake in which the rotor and stator are each rotatably supported in the housing of the brake, the rotor being adapted to be permanently connected to the shafting system to be braked and the stator having means connected thereto for restraining the stator against rotation when braking effort is required.

Conveniently the stator is mounted on a shaft rotatably supported in the housing and the said restraining means comprises a positive type brake, for example a friction brake mounted on the stator shaft. Thus, under normal running conditions of the hydro-kinetic brake and when braking is not required, the friction brake is disengaged and the fluid contained in the brake will cause the rotor and stator to interact in the manner of an hydraulic clutch or coupling. However, since the stator is free of restraint, the amount of power absorbed under these conditions is negligible. When braking is required, the friction brake on the stator shaft is applied and the stator brought to rest, and the arrangement becomes, in effect, a conventional type of hydro-kinetic brake which can be controlled by known means normally used on brakes or hydraulic dynamometers for the control of retarding effort.

One embodiment of the invention is illustrated in the accompanying drawing in which the sole figure represents a longitudinal section through an hydraulic brake according to the invention.

As will be seen from the drawing, the brake comprises a housing indicated generally at 1 and formed to provide a chamber 2 in which are positioned a rotor 3 and a stator 4, and bearing supports 5 and 6 in which are rotatably supported by means of ball bearings 7 a rotor shaft 8 and a stator shaft 9 respectively. Both the rotor and the stator are thus freely rotatably supported in the housing 1. The rotor shaft 8 terminates in a coupling flange 10 by which it can be permanently coupled to the shafting system to be braked, while the stator shaft 9 has secured thereto a drum or disc 11 of a friction brake (not shown). The chamber 2 and the stator 4 are shaped to provide an inlet compartment 12 in which water is admitted in known manner, the water being discharged through an outlet 13, suitably

seals 14 being provided on the shafts 8 and 9 respectively.

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892,314 PROVISIONAL SPECIFICATION

1 SHEET

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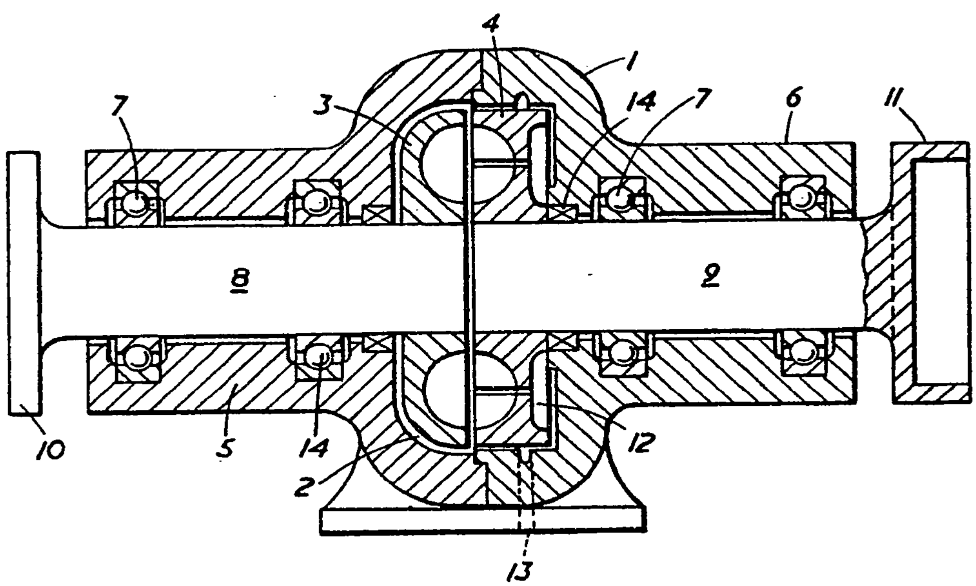

892,314 COMPLETE SPECIFICATION
1 SHEET
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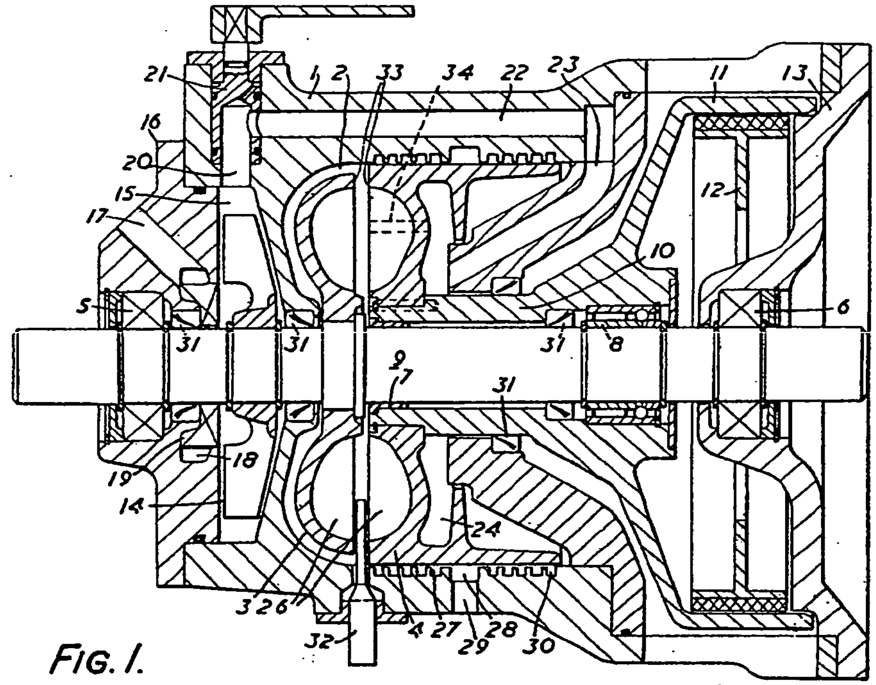

FIG. 1.

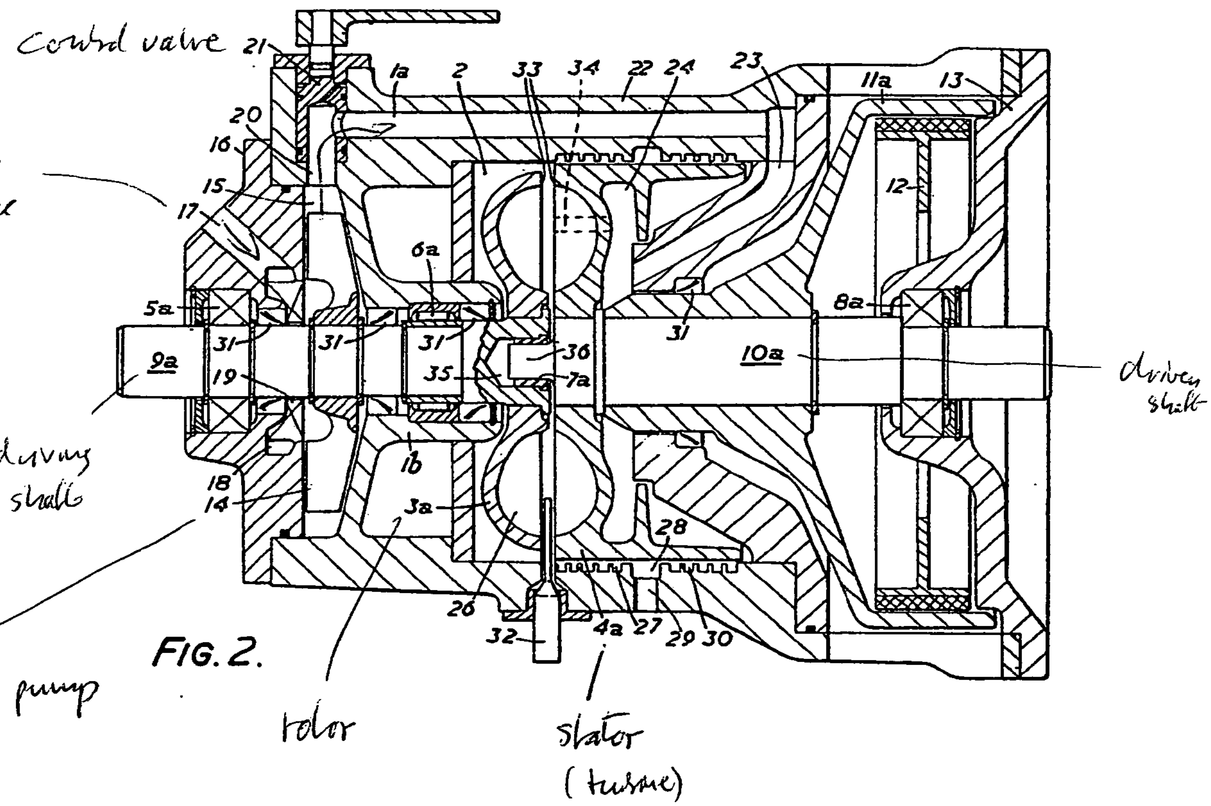

FIG. 2.